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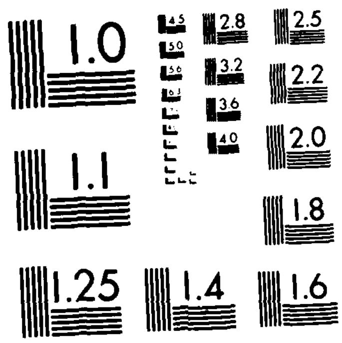

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AFGL-TR-82-0335

SOME NEW PRACTICAL MODELS FOR VISIBILITY FOR GERMAN LOCATIONS WHERE NO RECORDS EXIST

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Given only month, time of day, and the elevation and surrounding elevations for an arbitrary location in Germany, models are developed for estimating probabilities of visibilities less than a specified distance. The two-parameter Weibull model is used. For a given month and hour period, the parameters are functions of elevation and average elevation of the surrounding region. The models are developed using a somewhat sophisticated nonlinear, least squares regression program. Evaluation is accomplished using 'sample-reuse," a relatively new technique in which a valid independent evaluation of the model is made using

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20. (Continued)

the same observations used to develop the model.

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ACKNOWLEDGEMENT

We would like to acknowledge the invaluable assistance of Jon Dittmer, Ken Rodemann, and David Van Brackle in the preparation of this report.

1. Introduction

A goal of the Air Weather Service is to be able to state the probability that a weather element will have a value above a specified threshold for any location at any time. Many models have been developed for modeling such weather elements as visibility, ceiling, sky cover, precipitation, windspeed, etc., for locations where records exist. The modeling for locations where there are no records is a more difficult task. This report develops and evaluates some new models for estimating visibility probabilities for German locations where no records exist. The models require only knowledge of the elevation of the location and the average of the elevations a distance of 20 kilometers from the location in order to estimate visibility probabilities for a specified month and hour period. The next section outlines the work-to-date by the present authors on the problem of predicting visibilities at locations where no records exist.

2. Background of Previous Work on "Spreading" Visibility

At the University of Central Florida, under the sponsorship of the Air Force Geophysical Laboratory, several technical reports have been prepared on the subject of estimating visibility in data void regions, with particular reference to Germany. In AFGL-TR-81-0144, "Some Models for Visibility for German Stations," the Weibull distribution was used to fit visibility data for 30 stations in Germany. For each of the 30 stations, values of α and β were obtained for each month and for all 3-hour periods. For any distance x, the probability F(x) of visibility less than a distance of x miles is then given by the formula

$$F(x) = 1 - e^{-\alpha x^{\beta}}.$$

Measures of the accuracies of the predictions were also obtained. These, however, were based on the residuals of the least squares fits; and, as such, the standard deviations would be expected to be underestimates. Also, no attempt was made to predict visibility for locations where no records existed.

The first report in which an attempt was made to predict visibility for locations where no records existed was AFGL-TR-81-0313, "Modeling Visibility for Locations in Germany Where No Records Exist." In this report, the models were formulated by using the values for α and β from AFGL-TR-81-0144 and regressing these values on a large number of variables which were potential predictors of the values for α and β. These included such variables as station elevation, relative elevation, proximity to water, mean windspeed and various combinations (interactions) of these and other variables. The prediction equations for α and β were then refined by a sophisticated nonlinear regression program in which the sums of squares of the residuals minimized were not the residual differences between the values for α and β and their predicted values but were the differences between the empirical cumulative distribution function and the model cumulative distribution function. This latter regression produced a set of equations for predicting α and β from geographic and climatic predictor variables. One set of equations was produced for each month and time of day. These models were designated collectively as the "Variables Model."

A second set of models was produced by again using the above mentioned nonlinear regression program; this time using none of the predictor variables. The result was a pair of constants α, β for each month and time of day which gave the best fits for all stations. These models were designated collectively as the "Constants Model."

The measures of accuracy of the models used in this report were the resulting "mean square of the residuals." Since, again, this is essentially an internal estimate and is based on the same data used to produce the models, the RMS values, when interpreted as accuracy measures are optimistic estimates.

The third paper in the series, AFGL-TR-82-0187, "Evaluation of an Observation-based Climatology Model for Predicting Visibility for Data Void Locations in Germany," gives two independent evaluations of the "Constants" model developed in the previous report. Two methods were used. The first was a traditional method. The original 30 stations were regarded as a "calibration" set. A second set of 30 stations was used as an "evaluation" set. The second method involved a relatively new technique called "sample reuse" (also sometimes called crossvalidation), whose use has only recently been made practical due to the availability of "cheap" computing.

The "sample reuse" method evaluations were entirely consistent with the evaluations based on "calibration" and "evaluation" sets, and the report may be said to have confirmed the use of "sample reuse." Values of α and β for the "Constants" model were recalculated making use of all 60 stations.

The report AFGL-TR-82-0239, "Estimating a Family of Distributions with Applications to Climate Spreading," was an attempt to make available to a wider audience some methodologies developed in previous reports and, in particular, the work reported in AFGL-TR-81-0144. The report is an excellent example where the solution of a practical problem resulted in the development of new methodologies and basic research applicable to a much wider class of problems. Publication of this research in the scientific literature is expected.

The present report was first intended to be an independent evaluation of the "Variables" model of AFGL-TR-81-0144. However, since that model included as predictors for α and β variables which would ordinarily not be available for a station where no records existed, and since AFGL-TR-82-0187 demonstrated the ability of "sample reuse" to produce a valid independent evaluation of those models, it was decided to proceed otherwise.

Models were developed for each month and hour period (except hour periods 00-02 and 03-05) using only the variables elevation and relative elevation, whose values would ordinarily be available at locations with no previous records for visibility, and which had previously been confirmed to be useful for prediction purposes. Sample reuse was used to produce independent estimates of the accuracy of the models.

3. Methodology

Let $E_j(x_i)$ be the empirical probability (step function) that the visibility is less than x_i miles for the j^{th} station, using data from the RUSSWOs. The values for x_i are the following distances in miles: 1/4, 5/16, 1/2, 5/8, 3/4, 1, 5/4, 3/2, 2, 5/2, 3, 4, 5 and 6. Let

$$F_j(x;\ \alpha_j,\ \beta_j) = 1 - e^{-\alpha_j x^{\beta_j}}$$

where
$$\alpha_j = \gamma_0 + \gamma_1 * EL_j + \gamma_2 * AE_j$$
$$\beta_j = \delta_0 + \delta_1 * EL_j + \delta_2 * AE_j.$$

EL_j and AE_j are transformed and scaled values for the elevation at station j, and the average elevation at 20 equispaced locations on a circle of radius 20 kilometers and centered at the station. EL is the cube of the elevation in feet, divided by 10^9. AE is the cube of the average elevation in feet, divided by 10^9. The constants γ_0, γ_1, γ_2, δ_0, δ_1, δ_2 are determined by minimizing the expression

$$\sum_j \sum_i [E_j(x_i) - F_j(x_i;\ \alpha_j,\ \beta_j)]^2$$

That is, the constants are those which minimize the sum of squares of the differences between the empirical and model probabilities over all stations and all distance for which data are available. The constants γ_0, γ_1 and γ_2 are given in Exhibit 2.1, "Model Coefficients for Alpha," and the constants δ_0, δ_1, δ_2 are given in Exhibit 2.2, "Model Coefficients for Beta."

The models were evaluated by sample reuse. The method of sample reuse may be briefly described as follows. If there are n stations, n separate models are developed. For each model, one station is used as the evaluation set, with the remaining n-1 used as the calibration set. For each station, the root mean square (RMS) error of the modeling procedure is obtained. The RMS values for the individual stations are then pooled to obtain an overall RMS error for the procedure. The RMS values by month and hour are given in Exhibit 2.3.

Exhibit 2.4 gives the RMS for each station, averaged over all months and hour periods. The first column of RMS values gives the RMS values from sample reuse, that is, when all of the other stations were used in the model building process, and the specified station was used as the "evaluation set." The RMS values indicate how well that visibility would have been predicted if the station had been a station "for which no records exist," using a model based on all the other stations. For 54 out of the 60 stations, prediction would have been good. The stations which would not have been well predicted are Baumholder, Siegenberg, Kahler Asten, Plezen, Feldberg and Grosser Falk. The latter six stations have previously presented modeling problems. The second column of RMS values are the RMS values from a full regression for the model using all 60 stations. Two things ar remarkable. First, Feldberg and Grosser Falk show up as remarkab influential in the regression. This suggests that for both station there is a prediction variable that, if used in the model, would ha greatly improved prediction for these stations. Second, for the othe 58 stations the RMS values are little changed. This suggests (at least to the authors) that the use of the variables of elevation and relative elevation results in a quite good model for predicting visibility probabilities for specific months and hour periods.

Exhibit 2.5 gives the RMS values that resulted when all 60 stations were used to generate the model coefficients given in Exhibits 2.1 and 2.2. These are the RMS values over all stations and are internal estimates. Exhibit 2.3, and not Exhibit 2.5, should be used as a measure of the ability to predict visibility for locations in Germany where no visibility records are available. One reason for retaining Exhibit 2.5 in this report is to indicate that RMS values obtained from the regressions producing the model are overestimates of the model accuracies and instead an independent estimate should be used. It is worth repeating that sample reuse does provide independent estimates of the model accuracies! This is accomplished despite the fact that we do not have two sets of data--one for the determination of the model accuracies and one for the evaluation of the model.

4. Use of the Model

Problem 1: Find α and β for Koblenz for March 0900-1100 hours and use it to find probability of visibility less than 1.5, 2.0 and 6.0

miles. The elevation of Koblenz is 318 feet and the average elevation of the surrounding area is 900 feet.

Solution: From Exhibits 2.1 and 2.2 we have

$\alpha = .0848 + .00580\ (318)^3/10^9 - .00178\ (900)^3/10^9 = .0837$ and

$\beta = 1.26 - .00983\ (318)^3/10^9 - .0105\ (900)^3/10^9 = 1.252.$

Estimated probability of visibility less than or equal to x miles is

$$1 - e^{-.0837x^{1.252}}$$

The probabilities of visibilities less than or equal to distances of 1.5, 2.0 and 6.0 miles are thus estimated as .130, .181 and .546. These compare to the RUSSWO values of .090, .156 and .525.

Problem 2: Find α and β for Berus for September 1800-2000 hours and use it to find probabilities of visibility less than 1.5, 2.0 and 6.0 miles. The elevation of Berus is 1204 feet and the average elevation of the surrounding area is 1050 feet.

Solution: From Exhibits 2.1 and 2.2 we have

$\alpha = .0174 + .00305 \times (1204)^3/10^9 - .000689\ (1050)^3/10^9 = .0219$ and

$\beta = 1.40 - .0111 \times (1204)^3/10^9 - .00670\ (1050)^3/10^9 = 1.373.$

Estimated probability of visibility less than or equal to x miles is

$$1 - e^{-.0219x^{1.373}}$$

The probabilities of visibilities less than or equal to distances of 1.5, 2.0 and 6.0 miles are thus estimated as .037, .055 and .226. These compare to the RUSSWO values of .019, .027 and .140.

5. Summary

Given only month, time of day, and the elevation and surrounding elevations for an arbitrary location in Germany, models are developed for estimating probabilities of visibilities less than a specified distance. The two-parameter Weibull model is used. For a given month and hour period, the parameters are functions of elevation and average elevation of the surrounding region. The models are developed using a somewhat sophisticated nonlinear, least squares regression program. Evaluation is accomplished using "sample-reuse," a relatively new technique in which a valid independent evaluation of the model is made using the same observations used to develop the model.

6. References

Bean, S. J. and P. N. Somerville, "Evaluation of Models for 'Spreading' Visibility in Germany," AFGL-TR-82-XXXX, July 1982.

Bean, S. J. and P. N. Somerville, "Estimating a Family of Distributions with Applications to Climate Spreading," AFGL-TR-82-XXXX, 16 August 1982.

Somerville, P. N. and S. J. Bean, "Some Models for Visibility for German Stations," AFGL-TR-81-0144, 15 April 1981. ADA 104167

Somerville, P. N. and S. J. Bean, "Modeling Visibility for Locations in German Where No Records Exist," AFGL-TR-81-0313, December 1981. ADA 111890

LISTING OF EXHIBITS

Month	06-08	09-11	12-14	15-17	18-20	21-23
			Hour Period			
Jan	.186 .707e-02 -.154e-02	.212 .598e-02 -.272e-02	.143 .655e-02 -.296e-02	.128 .687e-02 -.278e-02	.131 .713e-02 -.188e-02	.109 .704e-02 -.509e-03
Feb	.179 .832e-02 -.300e-02	.176 .717e-02 -.328e-02	.961e-01 .659e-02 -.285e-02	.780e-01 .671e-02 -.274e-02	.831e-01 .697e-02 -.226e-02	.732e-01 .775e-02 -.125e-02
Mar	.121 .672e-02 -.164e-02	.848e-01 .580e-02 -.178e-02	.384e-01 .479e-02 -.132e-02	.285e-01 .461e-02 .119e-02	.307e-01 .510e-02 [illegible]	.307e-01 .554e-02 -.139e-02
Apr	.734e-01 .630e-02 -.133e-02	.365e-01 .486e-02 -.862e-03	.204e-01 .409e-02 -.107e-02	.153e-01 .400e-02 -.965e-03	.149e-01 .435e-02 -.770e-03	.144e-01 .433e-02 -.654e-03
May	.562e-01 .463e-02 -.114e-02	.235e-01 .399e-02 -.163e-02	.135e-01 .333e-02 -.129e-02	.977e-02 .275e-02 -.896e-03	.107e-01 .322e-02 -.840e-03	.131e-01 .375e-02 .336e-03
Jun	.527e-01 .452e-02 -.720e-03	.215e-01 .370e-02 -.158e-02	.119e-01 .283e-02 -.107e-02	.851e-02 .218e-02 -.621e-03	.898e-02 .275e-02 -.568e-03	.110e-01 .299e-02 -.600e-03
Jul	.445e-01 .365e-02 [illegible]	.186e-01 .310e-02 -.107e-02	.112e-01 .245e-02 -.934e-03	.855e-02 .189e-02 -.577e-03	.843e-02 .205e-02 [illegible]	.951e-02 .267e-02 -.785e-03
Aug	.979e-01 .327e-02 -.118e-02	.278e-01 .282e-02 -.580e-03	.138e-01 .218e-02 -.641e-03	.103e-01 .207e-02 -.422e-03	.101e-01 .239e-02 -.414e-03	.121e-01 .271e-02 -.355e-03
Sep	.221 .336e-02 -.230e-02	.706e-01 .352e-02 -.184e-02	.209e-01 .238e-02 -.981e-03	.146e-01 .233e-02 -.738e-03	.174e-01 .305e-02 -.689e-03	.239e-01 .389e-02 -.101e-02
Oct	.340 .290e-02 -.411e-02	.194 .388e-02 -.443e-02	.592e-01 .276e-02 -.209e-02	.407e-01 .395e-02 -.165e-02	.628e-01 .428e-02 -.199e-02	.792e-01 .507e-02 -.224e-02
Nov	.187 .850e-02 -.311e-02	.170 .752e-02 -.335e-02	.928e-01 .724e-02 -.278e-02	.862e-01 .752e-02 -.272e-02	.940e-01 .794e-02 -.229e-02	.925e-01 .801e-02 -.163e-02
Dec	.163 .701e-02 -.146e-02	.184 .589e-02 -.177e-02	.131 .625e-02 -.265e-02	.126 .678e-02 -.228e-02	.126 .689e-02 -.123e-02	.115 .742e-02 -.291e-03

Exhibit 2.1

Model Coefficients For α

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Month	06-08	09-11	12-14	15-17	18-20	21-23
Jan	1.05 -.920e-02 -.635e-02	1.01 -.872e-02 -.600e-02	1.13 -.923e-02 -.864e-02	1.15 -.952e-02 -.803e-02	1.16 -.105e-01 -.522e-02	1.12 -.969e-02 -.698e-02
Feb	1.02 -.944e-02 -.330e-02	1.05 -.892e-02 -.564e-02	1.21 -.971e-02 -.926e-02	1.21 -.103e-01 -.613e-02	1.22 -.108e-01 -.443e-02	1.16 -.104e-01 -.419e-02
Mar	1.14 -.960e-02 -.629e-02	1.26 -.983e-02 -.105e-01	1.36 -.102e-01 -.110e-01	1.33 -.103e-01 -.924e-02	1.37 -.111e-01 -.708e-02	1.34 -.105e-01 -.954e-02
Apr	1.21 -.102e-01 -.649e-02	1.32 -.923e-02 -.159e-01	1.16 -.937e-02 -.399e-02	1.08 -.956e-02 .483e-03	1.19 -.107e-01 -.560e-03	1.22 -.113e-01 .143e-02
May	1.27 -.876e-02 -.193e-01	1.33 -.639e-02 -.352e-01	1.09 -.479e-02 -.298e-01	1.05 -.566e-02 -.218e-01	1.10 -.762e-02 -.122e-01	1.18 -.900e-02 -.977e-02
Jun	1.33 -.812e-02 -.265e-01	1.41 -.595e-02 -.418e-01	1.23 -.538e-02 -.325e-01	1.21 -.803e-02 -.145e-01	1.25 -.913e-02 -.119e-01	1.36 -.109e-01 -.661e-02
Jul	1.43 [illegible] [illegible]	1.42 -.589e-02 [illegible]	1.14 -.474e-02 -.304e-01	1.04 [illegible] -.588e-02	1.19 -.968e-02 [illegible]	1.43 -.109e-01 -.111e-01
[illegible]	[illegible] -.100e-01 -.245e-02	1.50 -.833e-02 [illegible]	1.28 -.872e-02 -.110e-01	[illegible] .855e-02 [illegible]	[illegible] [illegible] -.516e-02	1.46 -.120e-01 -.506e-02
[illegible]	[illegible] [illegible] -.232e-02	[illegible] [illegible] -.150e-01	1.45 [illegible] [illegible]	[illegible] [illegible] [illegible]	1.40 [illegible] [illegible]	1.37 [illegible] [illegible]
[illegible]	[illegible] [illegible] [illegible]	.900 [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]	[illegible] [illegible] [illegible]
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Exhibit 2.2

Model Coefficients For β

Month	Hour Period 06-08	09-11	12-14	15-17	18-20	21-23	ALL
Jan	.118	.111	.100	.099	.115	.150	.117
Feb	.102	.089	.081	.081	.097	.132	.099
Mar	.092	.086	.079	.074	.084	.098	.086
Apr	.089	.078	.066	.064	.072	.080	.075
May	.085	.060	.040	.038	.052	.069	.060
Jun	.085	.055	.041	.046	.057	.074	.062
Jul	.087	.055	.036	.041	.056	.074	.061
Aug	.099	.069	.056	.050	.062	.088	.073
Sep	.105	.079	.067	.060	.079	.097	.083
Oct	.095	.085	.078	.075	.102	.126	.096
Nov	.094	.090	.074	.083	.102	.125	.095
Dec	.104	.102	.095	.097	.107	.151	.111
ALL	.097	.082	.071	.070	.085	.109	.087

Exhibit 2.3

RMS By Month and Hour (Sample Reuse)

WMO	Station	Lat (North)	Long (East)	Elev.	Rel Elev.	Sample Re-use RMS	Full Fit RMS
10616	HAHN AB	49.95	7.27	1650.	1267.	.062	.048
10610	BITBURG AB	49.95	6.57	1228.	1363.	.044	.042
10614	RAMSTEIN AB	49.43	7.58	780.	710.	.051	.052
10607	SPANGDAHLEM AB	49.97	6.70	1196.	1330.	.057	.055
10384	TEMPELHOF APRT	52.47	13.40	164.	164.	.058	.058
10755	ANSBACH AAF	49.32	10.63	1542.	1181.	.068	.064
10544	FULDA AAF	50.53	9.63	1010.	1650.	.045	.046
10869	ERDING AS	48.32	11.93	1522.	1525.	.064	.062
10765	FEUCHT AAF	49.38	11.18	1265.	1407.	.046	.045
10618	BAUMHOLDER AAF	49.65	7.30	1408.	1538.	.153	.154
10626	BAD KREUZNACH AAF	49.87	7.88	355.	825.	.071	.071
10971	BAD TOLZ AAF	47.77	11.60	2360.	2688.	.121	.102
10714	ZWEIBRUCKEN AB	49.22	7.40	1132.	938.	.041	.040
10633	WIESBADEN AB	50.05	8.33	470.	617.	.036	.036
10633	FINTHEN AAF	49.97	8.15	769.	948.	.048	.047
10763	FURTH AAF	49.50	10.95	1000.	1225.	.085	.085
10642	HANAU AAF	50.17	8.95	377.	408.	.037	.036
10852	GABLINGEN AAF	48.45	10.87	1530.	1550.	.084	.082
10653	GIEBELSTADT AUX AF	49.67	9.88	985.	950.	.060	.060
10687	GRAFENWOHR AAF	49.70	11.95	1370.	1510.	.063	.066
10734	HEIDELBERG AAF	49.40	8.65	369.	369.	.034	.034
10752	ILLESHEIM AAF	49.47	10.38	1060.	1250.	.084	.084
10659	KITZINGEN AAF	49.75	10.20	699.	899.	.051	.052
10763	NURNBERG	49.50	11.08	1053.	1053.	.062	.063
10729	COLEMAN AAF	49.57	8.47	334.	350.	.078	.077
10657	WERTHEIM AAF	49.77	9.48	1120.	1075.	.095	.096
10745	SCHWAEBISCH HALL AA	49.17	9.78	1303.	1632.	.046	.046
10712	SEMBACH AB	49.52	7.87	1052.	1315.	.037	.037
10862	SIEGENBERG GUNNERY	48.75	11.80	1325.	1450.	.140	.140
10738	ECHTERDINGEN ARPT	48.68	9.22	1306.	1200.	.056	.054
10501	AACHEN, DL	50.78	6.12	673.	775.	.081	.080
10224	BREMEN, GER	53.05	8.80	502.	250.	.043	.043
10305	LINGEN, GER	52.52	7.33	549.	250.	.040	.040
10427	KAHLER ASTEN, GER	51.18	8.50	2822.	1563.	.204	.188
11157	AIGEN ENNSTAL, OS	47.53	14.15	2139.	3350.	.056	.053
11448	PLEZEN/DOBRA, CZ	49.67	13.30	1194.	1400.	.130	.131
10900	BREMGARTEN, GER	47.90	7.63	699.	1438.	.044	.041
10948	OBERSTDORF, GER	47.40	10.30	2664.	3350.	.097	.080
10929	KONSTANZ, GER	47.68	9.20	1368.	1725.	.037	.036
11120	INNSBRUCK, OS	47.27	11.37	1962.	3400.	.069	.074
11150	SALZBURG, OS	47.80	13.02	1463.	2338.	.048	.047
10893	PASSAU, GER	48.58	13.50	1335.	1613.	.056	.055
10908	FELDBERG, GER	47.87	8.02	4898.	2550.	.280	.069
10921	NEUHAUSEN, DL	47.98	8.92	2648.	2463.	.072	.063
10510	NURBURG, GER	50.33	6.97	2064.	1425.	.085	.077
10515	KOBLENZ, DL	50.35	7.60	318.	900.	.066	.068
10532	GIESSEN, GER	50.57	8.72	640.	825.	.059	.060
10542	HERSFELD, DL	50.87	9.72	738.	1200.	.059	.060
10658	KISSINGEN, DL	50.20	10.10	704.	1213.	.039	.040
10671	COBURG, GER	50.27	10.97	1106.	1338.	.038	.039
10685	HOF, GER	50.32	11.90	1864.	1938.	.048	.057
10704	BERUS, GER	49.27	6.70	1204.	1050.	.056	.054
10727	KARLSRUHE, GER	49.02	8.40	394.	600.	.041	.041
10742	OHRINGEN, GER	49.20	9.53	909.	1075.	.049	.049
10788	STAUBING, GER	48.82	12.60	1155.	1350.	.084	.085
10791	GROSSER FALK, GER	49.08	13.30	4291.	2475.	.259	.064
10805	LAHR, GER	48.37	7.85	509.	800.	.074	.073
10837	LAUDHEIM, GER	48.22	9.93	1765.	1938.	.053	.056
10953	KAUFBEUREN, DL	47.87	10.63	2348.	2513.	.069	.062
10875	MUHLDORF, GER	48.25	12.55	1319.	1625.	.053	.053

Exhibit 2.4

RMS By Station

Hour Period

Month	06-08	09-11	12-14	15-17	18-20	21-23	All
Jan	.106	.098	.086	.083	.100	.140	[illegible]
Feb	.088	.074	.061	.060	.075	.120	.083
Mar	.075	.066	.056	.047	.060	.085	.066
Apr	.069	.058	.041	.035	.042	.053	.051
May	.068	.048	.031	.026	.030	.048	.044
Jun	.070	.048	.031	.026	.032	.047	.045
Jul	.071	.046	.029	.023	.030	.047	.044
Aug	.082	.053	.036	.028	.035	.063	.053
Sep	.095	.053	.050	[illegible]	.054	.073	.065
Oct	.087	.071	.057	.052	.081	.111	[illegible]
Nov	.082	.076	.064	.065	.087	.115	.083
Dec	[illegible]	.087	.079	.080	.090	.142	.097
All	.033	.063	.055	.051	.065	.094	.071

Exhibit 2.5
RMS By Month and Hour (Overall Fit)

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